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Evaluating Desired Conditions for Mexican Spotted Owl Nesting and Roosting Habitat

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The Mexican spotted owl (*Strix occidentalis lucida*) was listed as a threatened species in 1993, primarily because of concerns over the loss of late seral forest habitat to timber harvest and wildfire. A recovery plan prepared for this owl subspecies explicitly assumed that nesting (and/or roosting) habitat was a primary factor limiting distribution of Mexican spotted owls and provided four desired conditions for identifying and managing potential owl nesting/roosting habitat in forested habitat. We used data collected at nest sites of Mexican spotted owls in the Sacramento Mountains, New Mexico, to evaluate how well these desired conditions and associated forest structural attributes described nesting habitat in this area. All nest sites included in our analyses successfully fledged young during the study. These nest sites generally featured higher levels of the structural attributes included in the desired conditions (total basal area, density of trees >46 cm in dbh, percentage of basal area in trees 30–46 cm dbh, and percentage of basal area in trees >46 cm dbh) than the surrounding stand, yet only 46–87% of sampled nest sites met single desired conditions and only 22% met all four conditions simultaneously. The best generalized linear models using combinations of these four structural attributes plus canopy cover to distinguish between nest sites and random sites within owl home ranges all contained canopy cover and percentage of basal area in trees >46 cm dbh. Relative importance values were high for both of these attributes (1.000 and 0.983, respectively), and confidence intervals around parameter estimates included zero for all other attributes. The present combination of four desired conditions did not consistently identify nesting habitat in this area, required managing for levels of structural attributes that were greater than levels typically observed at successful owl nest sites, and did not include canopy cover, which was the single best predictor in the Sacramento Mountains. We recommend revising the desired conditions in the Sacramento Mountains to emphasize canopy cover and some attribute measuring the large tree component. We also recommend repeating this assessment in other geographic areas to determine how well the desired conditions for those areas describe nesting habitat for owls.

Keywords: adaptive management, basal area, canopy cover, large trees, management recommendations, Mexican spotted owl, recovery planning, *Strix occidentalis lucida*

The Mexican spotted owl (*Strix occidentalis lucida*) occurs widely throughout the southwestern United States and portions of the Republic of Mexico (Gutiérrez et al. 1995, Ward et al. 1995). This owl occurs in disjunct areas featuring rocky canyonlands or forested mountains and canyons (Ward et al. 1995), and its fragmented distributional pattern reflects the availability of such areas. In forested areas, the owl often inhabits forests with late seral characteristics (Ganey and Dick 1995) and was listed as a

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threatened species in 1993 because of concern over the loss of old forest habitat to timber harvest and wildfire (US Department of Interior Fish and Wildlife Service [USDI FWS] 1993).

A recovery plan prepared to guide efforts to recover populations of this owl explicitly assumed that nesting and roosting habitat was the primary factor limiting distribution of Mexican spotted owls (USDI FWS 2012, p. 68) and provided two key recommendations focused on protecting such habitat. The first recommendation aimed to protect occupied habitat by establishing Protected Activity Centers (PACs) around areas currently occupied by owls (USDI FWS 2012, p. 258). The second recommendation focused on managing replacement nesting habitat for Mexican spotted owls outside of PACs (USDI FWS 2012, p. 265–266). To meet this second objective, the plan proposed four "desired conditions" for identifying and managing "Forested Recovery Nesting/Roosting Habitat" (USDI FWS 2012, Appendix C, Table C.3). These desired conditions defined a set of structural conditions thought to be important in nesting habitat selection (USDI FWS 2012, p. 284) and were stratified by "ecological management units" (large geographic subdivisions defined within the range of the owl, hereafter EMUs) and by the two major forest types (mixed-conifer and pine [*Pinus* spp.]-oak [*Quercus* spp.]) used for nesting by Mexican spotted owls.

The USDI FWS (2012, p. 3) also emphasized the use of newly acquired information in an adaptive management framework (Moir and Block 2001, Evans et al. 2016) to improve management recommendations. Previously, Ganey et al. (2014a) used data on owl locations from a study of owl demography (Ganey et al. 2014b) in the Sacramento Mountains, New Mexico (Basin and Range-East EMU), to evaluate use of PACs by resident owls in that area. Here, we used data on nesting habitat from Ganey et al. (2013) to evaluate how well the desired conditions proposed for identifying and managing replacement nesting habitat in this EMU described nesting habitat used by resident owls. In the interest of full disclosure, four of the current authors (J.L.G., S.H., W.M.B., and J.P.W.) were members of the recovery team that proposed the desired conditions evaluated here.

Study Area

Our study area was located in the Sacramento Mountains of South-central New Mexico, within the Basin and Range-East EMU (USDI FWS 2012, Figure II.1), on lands managed by the Sacramento Ranger District, Lincoln National Forest (Kaufmann et al. 1998, Figure 4, Ward 2001, Figure 3.1). The Sacramento Mountains comprise a large montane island surrounded by a desert and semidesert matrix (Kaufmann et al. 1998, Ward 2001). Most of the study area occurred at elevations ranging from 2,130 to 2,980 m. Precipitation averaged 65 cm year^{-1} at Cloudcroft, New Mexico (2,652 m, located within the study area), with summer thunderstorms providing more than 60% of annual precipitation and most of the remainder occurring as winter snowfall (Kaufmann et al. 1998). Montane canyons dominated topography, with forests on most canyon slopes and ridgetops and a mix of forests and montane meadows common in canyon bottoms. Mixed-conifer forest was the primary forest type in the study area (Kaufmann et al. 1998). These forests were dominated in terms of basal area by white fir (*Abies concolor*) and/or Douglas-fir (*Pseudotsuga menziesii*). Other common species included southwestern white pine (*Pinus strobiformis*) and quaking aspen (*Populus tremuloides*). Ponderosa pine (*Pinus ponderosa*) was relatively uncommon, occurring mainly in drier sites, and blue (*Picea pungens*) and Engelmann (*Pinus engelmannii*) spruce occurred in some areas. Maples (*Acer* spp.) and Gambel oak (*Quercus gambelii*) were common in the understory at some sites, and the most common shrub species was rock spirea (*Holodiscus dumosus*). Portions of the study area at lower elevations were dominated by drier forest types. Mixed-conifer forest here was restricted to cooler microsites such as drainage bottoms and north-facing slopes in these areas, and stands were dominated by Douglas-fir and ponderosa pine with lower amounts of white fir. Woodlands of piñon pine (*Pinus edulis*) and alligator juniper (*Juniperus deppeana*) dominated many ridgetops and most south-facing slopes. Other slopes were dominated by ponderosa pine forest, sometimes with a prominent component of Gambel oak. Gray oak (*Quercus griseus*) and wavyleaf oak (*Quercus undulatus*) also were present in some areas.

Mexican spotted owls were well distributed across the Sacramento Ranger district, with 121 designated PACs within the district (Lincoln National Forest[1]). Current information suggests that the Sacramento Mountain owl population is somewhat isolated genetically, with most recruitment into the territorial population resulting from reproduction within the Sacramento Mountains (Barrowclough et al. 2006, Ganey et al. 2014b), supporting the importance of providing suitable nesting habitat to aid in maintaining or increasing numbers of Mexican spotted owls in this area.

Table 1. Minimum desired conditions for Forested Recovery Nesting/Roosting Habitat in mixed-conifer forest within the Basin and Range-East EMU.

Structural attribute	Variable acronym	Desired condition
Total tree basal area	TOTALBA	$\geq$33.3 m^2 ha^{-1}
% of basal area in trees 30–46 cm dbh	%BA30TO46	>30
% of basal area in trees >46 cm dbh	%BAGT46	>30
Density of trees >46 cm dbh	LTD	$\geq$37 trees ha^{-1}

Data from the USDI FWS (2012, Appendix C, Table C.3). The USDI FWS (2012, p. 284) specified that all conditions should be met simultaneously within a forest stand and that $\geq$20% of the mixed-conifer forest outside of PACs should be managed as Forested Recovery Nesting/Roosting Habitat in this area.

Methods

Desired Conditions

The USDI FWS (2012, Appendix C, Table C.3) proposed a set of four desired conditions focused on identifying appropriate stands for management as replacement nesting habitat and defining minimum acceptable levels of structural conditions for retention within such stands. This table also defined a target portion of the landscape to be managed as Forested Recovery Nesting/Roosting Habitat. The desired conditions defined minimum acceptable levels of total tree basal area, density of trees $\geq$46 cm in dbh, percentage of basal area in trees 30–46 cm dbh, and percentage of basal area in trees >46 cm dbh, with specific values for those levels varying among EMUs and forest types (Table 1). The USDI FWS (2012, p. 284) specified that all four desired conditions should be met simultaneously and explicitly assumed that stands meeting the desired conditions would contain $\geq$1 patch suitable for use by nesting owls and would provide adequate amounts of other habitat elements considered to be important, such as canopy cover and large snags and logs (USDI FWS 2012, p. 267).

Data Used

We used data collected during a study of Mexican spotted owl nesting habitat in the Sacramento Mountains (Ganey et al. 2013) to evaluate the desired conditions in the USDI FWS (2012, Appendix C,

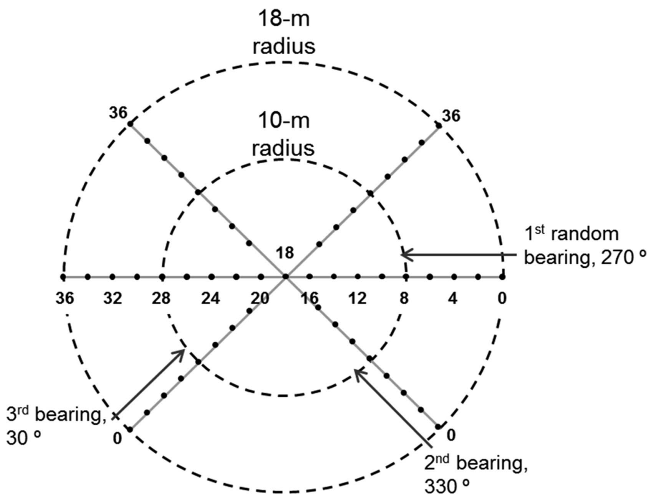

Figure 1. Schematic diagram of sampling methods used to sample forest structure at nest site, nest vicinity, and PAC plots in the Sacramento Mountains, New Mexico (plot types are described in the text). We sampled live and dead trees ≥30 cm dbh within a 0.1-ha circular plot and live and dead trees between 10 and 30 cm dbh, which were more abundant, within a nested 0.03-ha plot. We estimated overhead canopy cover along three separate line transects. Each transect was 36 m in length and centered on one side of the plot center tree. The first transect followed a randomly chosen bearing (270° in the example shown here), with the second and third transects offset by 60° and 120°, respectively, to ensure that they sampled different portions of the plot. We recorded the presence or absence of overhead canopy cover (≥2 m high) at 2-m intervals along the transects using a sighting tube (Ganey and Block 1994), except that we skipped points at 16, 18, and 20 m on the second and third transects to avoid oversampling at plot center (resulting in n = 48 sample points). Note that points are numbered only on the first transect in the figure and then only at every other sample point.

Table C.3) within mixed-conifer forest in the Basin and Range-East EMU (Table 1). We measured forest structural attributes in three types of spatially matched circular plots within our study area. Nest site plots were centered on a nest tree used by Mexican spotted owls between 2002 and 2011. Importantly, all of these nest sites supported successful reproduction during the study (i.e., resident owls fledged ≥1 owl in at least 1 year at each nest site included in analyses). Two kinds of associated random plots were sampled. Nest vicinity plots were centered on a random tree ≥25 cm in dbh located within 200 m of the nest tree and were intended to sample conditions in the general vicinity of nest sites. PAC plots were centered on a random tree ≥25 cm dbh located within a 201-ha area centered on the nest tree. These plots were intended to sample areas available within owl PACs (minimum PAC area = 243 ha) (USDI FWS 2012, p. 258).

We sampled each plot once between 2006 and 2011. At each site, we measured trees with dbh >30 cm within a 0.1-ha circular plot and trees with dbh ≥10 and ≤30 cm within a nested 0.03-ha plot and recorded dbh of all trees (Figure 1).

We also sampled overhead canopy cover within our plots. Although canopy cover was not included in the desired conditions (Table 1), we included it in some of our analyses because previous studies consistently identified canopy cover as an important predictor of Mexican spotted owl nesting habitat (Ganey and Dick 1995, Seamans and Gutiérrez 1995, May et al. 2004, Ganey et al. 2013). We estimated overhead canopy cover along three separate line transects (Figure 1). Each transect was 36-m in length and centered on one side of the plot center tree. The first transect followed a randomly chosen bearing, with the second and third transects offset by 60° and 120°, respectively, to ensure that they sampled different portions of the plot. Sample points were located at 2-m intervals along the transects, except that we skipped sampling at points 16, 18, and 20 m along the second and third transects to avoid oversampling at the plot center (resulting n = 48 sample points). We recorded the presence or absence of overhead canopy cover (≥2 m high) at each point using a sighting tube (Ganey and Block 1994).

Table 2. Numbers and types of plots included in three separate analysis steps used to evaluate desired conditions for Mexican spotted owl nesting habitat in the Sacramento Mountains, New Mexico.

Analysis step[1]	Plots used[2]	No. of plots included
1	Nest site, nest vicinity	46 of each type
2	Nest site, nest vicinity	46 of each type
3	Nest site, Protected Activity Center	96 of each type

[1] Analysis Step 1 compared levels of forest structural attributes included in four desired conditions (see Table 1 for structural attributes) between 46 pairs of nest site and nest vicinity plots located within the same stand as mapped by the USDA Forest Service (spatial data were obtained from www.fs.fed.us/r3/gis/lin/Base_Vegetation.zip). Only pairs of plots from the same stand were used because the intent was to compare nest sites with random areas within the same stand. Step 2 used the same plots as Step 1 and estimated the proportions of nest site and nest vicinity plots that met the four desired conditions (Table 1) simultaneously, as well as the proportions meeting each desired condition singly. Step 3 used the continuous levels of the structural attributes included in the desired conditions, plus canopy cover, to distinguish between nest site plots and PAC plots. PAC plots were used in this step to sample random areas within areas used by owls. These plots thus did not need to be in the same mapped stand as nest site plots, and we expanded the sample to include 96 pairs of plots.

[2] Nest site plots were centered on a nest tree used by Mexican spotted owls. All nest sites included in our analyses successfully fledged young during the study. Nest vicinity and PAC plots were centered on a random tree ≥25 cm dbh located within 200 or 800 m of the nest tree, respectively.

Evaluating the Desired Conditions

We used the collected data to estimate levels of the structural attributes included in the four desired conditions (Table 1), plus canopy cover, for all plots. We evaluated the desired conditions in three separate steps (Table 2 and below).

Step 1: Comparing structural attributes of nest site and nest vicinity plots. We compared the structural attributes represented in the four desired conditions between 46 pairs of nest site and nest vicinity plots, where both plots occurred in the same forest stand as delineated by spatial coverage showing boundaries of stands as mapped by the US Department of Agriculture (USDA) Forest Service.[2] We included plots only in mixed-conifer forest because the desired conditions in the Basin and Range-East EMU were specific to this forest type. We used nest vicinity plots to represent random areas within the nest stand and estimated the difference in structural attributes between plots as nest site value − nest vicinity value. For each attribute, we used a one-sided Wilcoxon signed-rank test (Conover 1999) to test the null hypothesis that the mean difference was ≤0 (versus the alternative hypothesis that the mean difference was >0). Failure to reject this null hypothesis provided evidence that nest sites featured greater levels of these four attributes than the surrounding stand, implying that nest site plots should meet the minimum desired conditions that were specified for use at the stand scale.

Step 2: Estimating proportions of nest site and nest vicinity plots meeting desired conditions. Because the USDI FWS (2012, p. 284) specified that all desired conditions should be met simultaneously, we estimated proportions of nest site and nest vicinity plots located within the same stand that met all desired conditions simultaneously, using the 46 pairs of plots described above. We also estimated proportions of these plots that met single desired conditions to explore differences in agreement levels among single desired conditions. We again used nest vicinity plots in this analysis to represent random areas within the nest stand.

Step 3: Modeling relative importance of five forest structural attributes in identifying Mexican spotted owl nesting habitat. Proportions of nest sites meeting most desired conditions in Step 2 were relatively low (see Results). This could indicate that the attributes represented in the desired conditions were not good predictors of owl nesting habitat or that they were good predictors, but the values used to define minimum levels for desired conditions were not appropriate. To explore this issue, we used generalized linear models with a binary logistic response variable to distinguish between 96 nest sites and an equal number of PAC plots (intended to represent random areas within owl home ranges), with all plots located in mixed-conifer forest. Predictor variables in these models included the four structural attributes in the desired conditions (Table 1) plus canopy cover. Data inputs for predictor variables were the continuous empirical values observed in sampled plots, standardized to zero mean with unit variance (Legendre and Legendre 1998) to facilitate interpretation of parameter estimates. We evaluated 32 models representing all possible subsets of the five predictor variables in the R computing environment using the glmulti package (Calcagno 2013, R Core Team 2013). We ranked models by the change in Akaike's information criterion corrected for small sample size (ΔAICc), computed model weights after Burnham and Anderson (2002), and estimated relative variable importance by summing model weights across all models containing that variable. Variable importance was informative in this context because all variables were included in the same number of models (Doherty et al. 2012). We calculated model-averaged parameter estimates and 95% confidence intervals (CIs) around those estimates using unconditional variance (Burnham and Anderson 2002) for all standardized variables.

Results

We used 46 pairs of nest site and nest vicinity plots in analysis Step 1 and Step 2 (Table 2), because only these pairs of plots occurred in the same stand as mapped by the USDA Forest Service. Step 3 compared nest site plots to PAC plots, and this step did not require pairs of plots that were located in the same mapped stand. Consequently, we expanded the sample of plots used here to include 96 nest site plots and 96 PAC plots (Table 2). All plots used in our analyses were located in mixed-conifer forest. All nest site plots included in the analyses were used by owls from 2002 to 2011, and all of these nest sites successfully fledged young during this period.

Step 1: Comparing Nest Site and Nest Vicinity Plots

The mean differences in the structural attributes featured in the desired conditions between pairs of nest site and nest vicinity plots in the same stand were positive for all attributes, indicating that nest site plots generally featured greater levels of these attributes than random plots within the same stand (Table 3). The differences between paired plots were highly significant for %BAGT46 and LTD, marginally significant for %BA30TO46, and nonsignificant for TOTALBA (for definition of acronyms, see Table 1). Thus, the primary difference between nest sites and the surrounding stands was the greater abundance of large trees at nest sites.

Table 3. Differences in selected forest structural attributes between 46 pairs of Mexican spotted owl nest site plots in mixed-conifer forest within the Sacramento Mountains, New Mexico, and nest vicinity plots located within the same stand (as delineated by USDA Forest Service stand maps).

Structural attribute[1]	Mean difference	95% CI	P^2
TOTALBA	3.6	−0.4 to 7.5	0.144
%BA30TO46	4.1	0.1 to 8.1	0.046
%BAGT46	13.4	4.8 to 22.1	0.005
LTD	18.6	6.0 to 31.1	0.009

Spatial data were obtained from www.fs.fed.us/r3/gis/lin/Base_Vegetation.zip. Differences were computed as nest site plot value − nest vicinity plot value.
[1] Variable acronyms are defined in Table 1.
[2] *P* value from one-sided Wilcoxon signed-rank test.

Table 4. Percentages of paired Mexican spotted owl nest site and nest vicinity plots in the Sacramento Mountains, New Mexico, that met individual desired conditions or the combination of four desired conditions.

Desired condition[1]	Nest site plot	Nest vicinity plot
All four desired conditions	21.7	6.5
TOTALBA	58.7	41.3
%BA30TO46	45.7	63.0
%BAGT46	87.0	58.7
LTD	73.9	54.3

Conditions were from the USDI FWS (2012, Appendix C, Table C0.3). Pairs of plots ($n = 46$) were included only if they occurred in the same stand as mapped by the USDA Forest Service (spatial data are available at www.fs.fed.us/r3/gis/lin/Base_Vegetation.zip) and in mixed-conifer forest.
[1] Variable acronyms and desired conditions are defined in Table 1.

Step 2: Estimating Proportions of Nest Site and Nest Vicinity Plots Meeting Desired Conditions

Only 21.7 and 6.5% of paired nest site and nest vicinity plots within the same stand met all four desired conditions (Table 4). The proportions of plots that met individual desired conditions varied widely but were greater for nest site than for nest vicinity plots for all attributes except %BA30TO46. The desired conditions related to the large tree component (%BAGT46 and LTD) were both met by >70% of nest site plots but by <60% of nest vicinity plots, suggesting that these conditions were more useful in identifying nest "sites" than nest "stands." These two conditions based on the large tree component also were highly correlated (Pearson's $r = 0.832$, $P < 0.001$) and thus probably redundant. The desired condition based on TOTALBA was met by lower proportions of both nest site and nest vicinity plots, and the desired condition based on %BA30TO46 was met by <50% of nest site plots.

Step 3: Modeling Relative Importance of Five Forest Structural Attributes in Identifying Mexican Spotted Owl Nesting Habitat

We evaluated 32 models including combinations of the structural attributes featured in the four desired conditions, plus canopy cover, to distinguish between nest site and PAC plots. Seven models comprised the 95% confidence set based on model weights (Table

Table 5. Model selection results for generalized linear models comparing five forest structural attributes among 96 Mexican spotted owl nest sites used from 2002 to 2011 in mixed-conifer forest in the Sacramento Mountains, New Mexico, and an equal number of random plots sampled within the home ranges of those owls.

Model structure[1]	ΔAICc[2]	Model weight[3]
CANCOVER + %BAGT46 + %BA30TO46	0.000	0.354
CANCOVER + %BAGT46	1.537	0.164
CANCOVER + %BAGT46 + %BA30TO46 + LTD	1.920	0.135
CANCOVER + %BAGT46 + %BA30TO46 + TOTALBA	2.095	0.124
CANCOVER + %BAGT46 + LTD	3.284	0.069
CANCOVER + %BAGT46 + TOTALBA	3.628	0.058
Global (all five predictors)	3.932	0.050

Thirty-two candidate models were evaluated, with results shown here for seven models comprising the 95% confidence set based on model weights.
[1] Variable acronyms are defined in Table 1, except for CANCOVER (% canopy cover).
[2] Change in AICc relative to the model with the lowest AICc.
[3] Model weights were calculated following Burnham and Anderson (2002).

Table 6. Model-averaged parameter estimates, along with 95% CIs and relative importance estimates, from models using five forest structural attributes to distinguish between 96 Mexican spotted owl nest sites used from 2002 to 2011 in mixed-conifer forest in the Sacramento Mountains, New Mexico, and an equal number of random plots sampled within the home ranges of those owls.

Parameter[1]	Estimate[2]	95% CI	Importance[3]
Intercept	0.506	0.444 to 0.568	1.000
CANCOVER	0.141	0.075 to 0.207	1.000
%BAGT46	0.162	0.066 to 0.257	0.983
%BA30TO46	0.049	−0.043 to 0.141	0.668
LTD	0.011	−0.040 to 0.063	0.300
TOTALBA	−0.003	−0.033 to 0.028	0.275

[1] Variable acronyms are defined in Table 1, except for CANCOVER (% canopy cover).
[2] Estimates shown are for standardized variables used in candidate models to facilitate comparison among attributes that differed in scale of observation.
[3] Relative importance was computed by summing model weights of all models containing that attribute ($n = 32$ models for intercept and 16 models for all other attributes).

5). CANCOVER and %BAGT46 were included in all seven models, %BA30TO46 appeared in four models, and LTD and TOTALBA each appeared in three of these models. The 16 models lacking CANCOVER collectively contributed <0.03% of total model weight, relative importance estimates were greater for CANCOVER and %BAGT46 than for all other variables, and CIs around parameter estimates included zero for the other three attributes (Table 6). CANCOVER was not significantly correlated with any of the four attributes included in the desired conditions (all $P <$ 0.103), suggesting that it measured an aspect of nesting habitat not represented by those attributes.

Discussion

The overall goal of the recovery plan for the Mexican spotted owl is to recover populations of owls and their habitat to a point where they no longer require special protection under the Endangered Species Act (USDI FWS 2102, p. 68). Key parts of the recovery strategy focused on protection and management of owl nesting habitat, which was assumed to limit owl distribution and therefore abundance. One key recommendation focused on protecting areas currently or recently occupied by owls, assuming that occupancy by resident owls provided direct evidence that such areas deserved protection. Current evidence from the Sacramento Mountains suggests that this recommendation is working as intended to protect areas receiving consistent use by owls over time (Ganey et al. 2014a).

A second set of recommendations, which we evaluated here, focused on identifying and managing replacement owl nesting habitat outside of currently occupied areas, based on a set of four desired conditions describing minimum structural attributes for nest stands. This is a valid objective, as additional nesting habitat will be required to replace nesting habitat lost to forest succession and disturbance processes, as well as to support additional pairs of owls as the owl population grows. Our results indicated that this set of desired conditions required managing for levels of structural attributes that exceeded the levels typically observed in successful nest sites, however. As a result, they failed to identify 78% of nest sites used by owls in our study as nesting habitat (Table 4). All of these nest sites supported successful reproduction during the study, suggesting that the nesting habitat evaluated here was of adequate quality. The desired conditions also did not include canopy cover. Canopy cover was the best of the predictor variables evaluated here in distinguishing owl nest sites from random sites. The desired conditions included attributes such as total basal area that were not good predictors in this area, however.

We recognize that wildlife habitat is multidimensional and that management recommendations focused on one or a few characteristics of such habitat represent a vast oversimplification. These recommendations can be useful to managers charged with conserving wildlife habitat but do not capture the complexity of the habitat selection process. Selection of nesting habitat by Mexican spotted owls undoubtedly is influenced by factors beyond the nest site itself. Such factors may include pattern, composition, and dynamics of the surrounding landscape, abundance and habitat use of important prey species and predators in that surrounding landscape, and patterns of human disturbance. Our understanding of these and other factors and how they influence habitat selection by Mexican spotted owls is limited, and further work aimed to better understand these relationships is needed to improve recommendations for conserving populations and habitats of this owl.

In the meantime, our results suggest that the current desired conditions may limit protection to areas suitable for owl nesting and that there is considerable room for revising and improving the desired conditions. We recommend that the Mexican Spotted Owl Recovery Team use results from this study, as well as other appropriate data sources, to revise the desired conditions for the Sacramento Mountains. That revision should include fewer criteria and should emphasize canopy cover and the large tree component rather than attributes such as total basal area. We also recommend repeating this assessment in other geographic areas to determine how well the desired conditions proposed for those areas describe nesting habitat for owls. Ecological variability is pronounced within the range of this owl, and we are not comfortable extrapolating the results from this study to other geographic areas with different desired conditions (USDI FWS 2012: Appendix C, Table C.3).

Endnotes

1. Spatial data are available at www.fs.fed.us/r3/gis/lin/Mexican_Spotted_Owl.zip.
2. For more information, see www.fs.fed.us/r3/gis/lin/Base_Vegetation.zip.

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